Interactive co-construction to study dynamical collaborative situations.

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Abstract

The purpose of this paper is to present the principle of our framework CoPeFoot dedicated to the study of dynamic and collaborative situations. This research work aims to instate learning by the co-construction of such situations. The article starts by recalling constraints induced by such situations. Next, it introduces interactive co-construction assumption and their implementation in CoPeFoot. In fact, this implementation is based on two steps in CoPeFoot: firstly, machine learning for behavior modeling, using imitation of real users and secondly, refining this behavior by using interaction between the user and the simulation, enhanced by additional information called augmented virtuality. In order to do that, CoPeFoot lies on context base reasoning which is presented. The article ends by a first evaluation of this work.

keywords : Co-construction, Context, Case Base Reasoning, Dynamical Situations, Team Sport.

1 Introduction

Our research work aims to study collaborative and dynamic situations through virtual environments [4, 5]. These kinds of situations are especially interesting related to specific psychological features [13]. Typically, we can meet them in the team sport area, which is our experimental aid [2]. Inside the virtual environment, users may be able to interact with autonomous agents and/or human team members [23]. Various combinations of multiple trainees, human or virtual, may be brought together for a training exercise. In this perspective, and in collaboration with experts in team sport, we develop the simulation tool CoPeFoot (for *Collective Perception in Football*). This interactive simulator lies on the tool for virtual reality AREVI [16][1]. CoPeFoot is meant for training coaches or referees. Football players training requires more specific skills, such as technical gestures, which are not within the scope of our work. However, our work focuses more on collective decision-making than on technical skills. In this view, two problems must be investigated:

1- Dynamic and collaborative situations cannot be described by sequences or synchronization unlike to procedural activities [8]. Decision making in these complex environments is characterized by severe time stress, high stakes, uncertainty, vague goals, and many organizational constraints [9]. Consequently, the outcome of players' actions are practically unpredictable. Moreover, a lot of psychological considerations must be taken

[1] AREVI is build-up by the LISyC (http://lisyc.univ-brest.fr) and is available on http://sourceforge.net/projects/arevi/

into account (weariness, errors), as well as physical considerations (wind, state of the grass, ...). Scenarios or sequences are reduced to episodic local modifications, without temporal persistance.

2- Interactions between protagonists (virtual or human teammates and opponents) have to be conducted in a manner resembling real-life contexts [20]. The behavior of virtual players has to be believable. This credibility is relative to the domain and to the aim of the simulation. We distinguish credibility from efficiency: In order to be relevant, the simulation must exhibit behavior which can be well-identified by users. The virtual simulation must cross refer to the real experience. The definition of these behaviors lies on psychological considerations rather than on mathematical optimization. Consequently, they are not easily formalizable.

The simulation setting of dynamic and collaborative situations cannot be obtained by the use of classical virtual story telling tools or languages [10]. Likewise, systematic approaches, such as reinforcement learning [26] or classifier systems, [18] are conflicting with the credibility assumption. Even if these practical methods are used to define behaviors in collaborative and dynamic situations [24, 19, 22], they are based on optimization criterion. Consequently, the generated behavior is not natural and cannot be used for human training or study. To follow this way, one must define criterion as difficult to obtain as an explicit description of the behavior itself! For these reasons, we argue that the co-construction of knowledge and know-how, by the way of interactions between experts and machine is a relevant proposition. To do that, virtual reality and augmented virtuality (addition of extra representations into the virtual universe) allow rich interactions between users and models. It is necessary to define relevant interactions and associated behavioral models. Our contribution lies on the use of case base reasoning [1] associated with context modelisation [15] for the co-construction of dynamic and collaborative situations. The plan of this paper is as follows. The first section 2.1 clarifies the concept of interactive co-construction. Next, we present briefly the functioning principles of CoPeFoot, especially the context base reasoning (section 2.2).

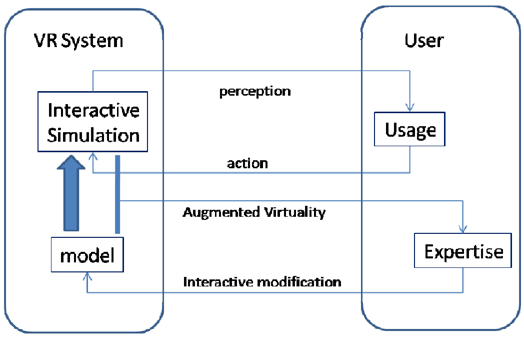

Figure 1: Interactive co-construction

Section 2.3 introduces the setting up of co-construction with CoPeFoot. In the final section 3, we focus on results related to a first credibility evaluation felt by some users.

2 Interactive co-construction

2.1 Principle

Interactive co-construction concept is based on both constructivist assumptions [21] and enactionism [28], even on interactionism [6] point of view about cognition. Interactions not only allow the user to create his own-representation of a problem but allow the user to modify the problem itself. Conversely, such modifications will affect future interactions and so on. There is a construction of the representation of the problem and of the problem itself. It's a co-construction. Moreover, these interactions occur in a social environment because protagonists share the same workplace, the common problem and the same goal. In our instance, the problem is to understand and/or to build collaborative and dynamical situations. Augmented virtuality is used to allow the modification of simulated situations. To do that, graphical interactive objects stand for virtual users behavioral models refinements. Consequently, we use a double loop of interactive simulation, described by figure 1. To carry out this double loop, we use context base reasoning within a virtual environment. We will now explain the principles of context base reasoning.

2.2 Context base reasoning within CoPeFoot

CoPeFoot rests on the multi-agent classical assumption that interaction between individual models allows to reach relevant collective behavior [14]. Our constraints of credibility led us to consider context as a modeling key element. Moreover, the co-construction purpose of our work led us to use case base reasoning (CBR) principles to carry out action selection of virtual players. Indeed, this kind of reasoning comes from analogy reasoning in the area of psychology [1]. Each encountered situation can be associated with another similar well-known and well-resolved situation. The question is to define how to associate situations to choose the more relevant and how to adapt one situation to another. With a relevant and tractable adaptation, we hope to obtain improvable human like behavior for co-construction. In the CBR area, some studies focus on the use of the user experience with the help of interaction traces [12]. For example, within the MUSETTE model [11], different steps allow to collect traces with the help of an observer agent. Such traces are analyzed and transformed in order to be presented to the user who can interact with them.

Our approach follows the same way considering that traces are cases. Each case is based on the representation of interactive context (which also includes actions and intentions). In the area of knowledge management, complementary use of CBR and context is frequently used [7]. In our case, a context is a tuple of perceptions. Each perception is defined by semantics considerations on the domain (here, football). Examples of such perception are the fact that a player is marked (followed by an opponent) or the fact that a team mate call for the ball. Technical description of our selection mechanism is out of the scope of this article. For mark, we can find some common features with the dynamical memory of CHANK [25]. Interested readers can carry forward [5, 3]. Here is an overview of this mechanism: Each perception is a predicate which use variables. Each variable can be unified with values coming from the simulation. Thereby, perceptions are generics and are brought together in a tree which organizes the case base. This organization enables us to bring similar cases together, and thus to obtain an anytime research algorithm. Figure 2 summarizes the initial simulation loop of CoPeFoot : Context is a filter and a data analyzer of physical perception coming from AREVI (objects, sounds, time). Outputs of this filter are perceptions like qualitative distances between players, information on marking, stress, and so on ... This is the CBR *elaboration* step. This context is compared with cases of the base and allows the selection of one case (*recall* step). Finally, with the help of semantics information associated to the context, the case is adapted to the current situation and the virtual player can act in the virtual universe (*adaptation*).

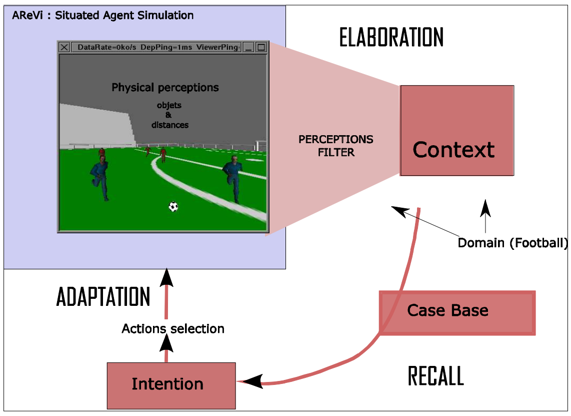

Figure 2: Context base reasoning within CoPeFoot

2.3 The co-construction double loop within CoPeFoot.

The co-construction principle (figure 1) is implemented within CoPeFoot in the following manner: During the interactive simulation of dynamic and collaborative situations, one or some users guide one or some avatars. Generally, they try to succeed in a specific exercise. It is the **stage 1** (imitation) of the figure 3: For each action performed by the user, the system tries to learn a case representative of the current state of the simulation. By this way, it improves the base and then learns by imitation.

Corresponding UML[2] activity chart is described on figure 4. Remember that a case includes not only context but also the intention of the player and a set of potential actions. The intention can be estimated with the help of semantics information associated with actions. During this stage, each time a new case is inserted, one timed maker is memorized. This marker will be used during the second stage (see next subsection).

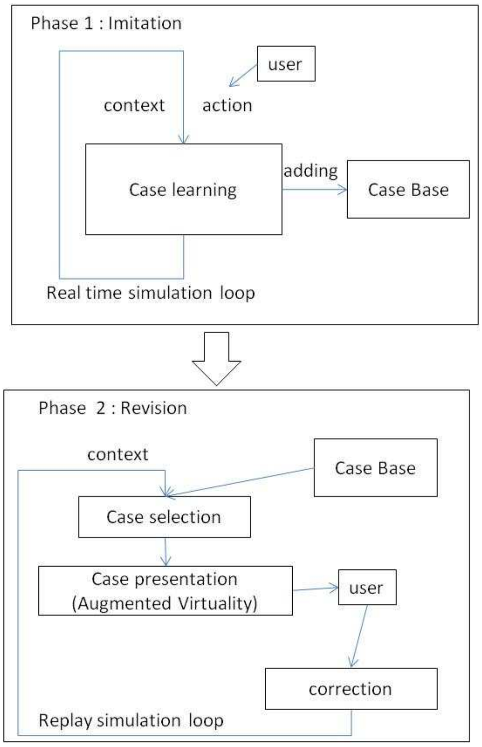

Figure 3: The two stages of the co-construction

This machine learning algorithm works *a priori* because it is not based on a human explicitation by the user itself. The algorithm can not do more than statistical estimation on the frequency of user's choices to estimate intention. In other words, the context is not well-organized or hierarchized to take into account the psychological influence of each perception for each decision. In fact, the recalling step of the case base reasoning cycle is using weight associated with each perception and relative to each case. During the learning stage, no weight is computed. Consequently, inserted cases are not really relevant from a human decision point of view and then, they are not appropriate for a good generalization in the base. Indeed they include all possible perceptions of the player, more or less relevant. This creates an information noise. If such cases are reused for the control of a virtual player in another exercise, they risk to be inadequately closed together by the recall step of the CBR. Simulated behaviors will become unbelievable to improve the case base with the help of augmented virtuality.

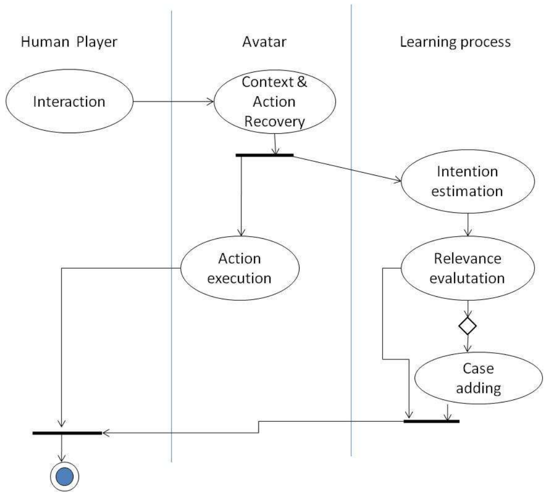

Figure 4: UML Activity chart of the imitation learning stage

The second stage (**stage 2** : revision) uses the case base as memorized traces. With the help of this traces, it is possible to replay the exercise. The avatar of the user becomes an autonomous virtual player. Such replay can be used to review the same sequence, like a 3D video recorder, but from another point of view. Such a tool is really relevant for training [17]. Moreover, during this stage, some new graphical objects are included in the virtual universe. This augmented virtuality aims to express features of the context, relative to the domain, which can be the cause of a decision. The user can interactively modify these features in order to explicit the decision-making from a human perspective. It is the second loop of the co-construction principle (see figure 1).

To do that, each time a timed marker is encountered by the simulator, the simulation is stopped. The user must select contextual features which seem important

[2] Unified Modeling Langage (http://www.uml.org/)

to him to make the actual decision. He must also affect a weight to each remaining features. This weight will be used in the future by the recall step of the CBR. A mechanism allows the revision of the case base (deleting unused perception for the case, adding weight and re-ordering the case base tree) to improve the human like aspect of the decision-making of the virtual user.

Figures 5 and 6 illustrate this stage : During the replay, the user can walk-around the scene and visualize contextual features built during the first stage. Examples of features are the following: A crossed ball close by a player means that he is calling for the ball. A compass means the perception of orientation, an arrow means the perception of a distance, a red circle means that a player is marked, and so on.

The user deletes some of this contextual perceptions or affects a weight to the others. He can also correct the intention and the action associated with the case. When he does that, he takes part to the construction of the situations. Furthermore, he observes the consequence of his modification. This observation helps him to understand the collaborative situation.

Figure 5: Example of stage 2 : The restituation by the 3D video recorder. All possible perceptions are displayed without any hierarchy.

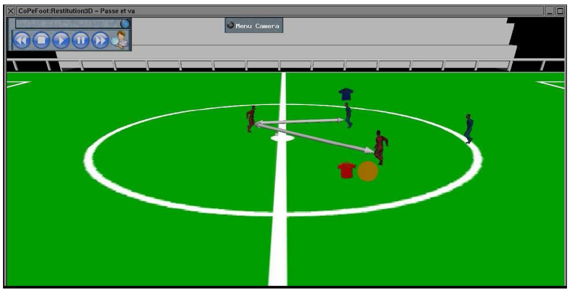

Figure 6: Example of stage 2 (suite) : Elimination of some contextual features and weighting of others.

Whatever the user is - player, referee or handler - he makes some back and forth between stages 1 and 2. He can play with other protagonists with the distributed version of CoPeFoot which do the some things. By this way, the system allows a social construction of the representation of the behavior of players within dynamical and collaborative situations.

3 Evaluation

We have insisted on the behavioral credibility needed for our purpose of studying collaborative and dynamical situations. We have claimed two assertions:

1. The co-construction allows the improvement of the credibility of the interactive simulation. The two reasons are that : 1) we take into account a human point of view of the decision-making instead of using rational and optimized behaviors and 2) by some back and forth between stage 1 and stage 2 of CoPeFoot, the behavior and the situation are progressively modeled.

2. This approach allows a better appropriation of dynamic and collaborative situations by users. This appropriation leads to the learning and the understanding of such situations.

These two assertions must be evaluated. In a first time, we focus on the first one. It is essential to carry out the second one. To do that, we have made an experimentation inspired by the TURING Test. The purpose is to evaluate the part of error for the recognition of autonomous virtual players rather than avatar (representation of a player controlled by a real human). CoPeFoot is distributed on the network and the name of user can vary from 0 to 22.

The evaluation protocol is this one : We use a case base defined by the way of stage 1 and 2 by expert and novice. We don't evaluate these stages. Twenty persons are divided in five clusters. Two servers allow two simulations in the same time in order to avoid communication beetwen persons in the same simulation. In the same way, the persons are distributed into three different rooms. They don't know how many players are avatar or autonomous agent. This number is given randomly by the program for each simulation.

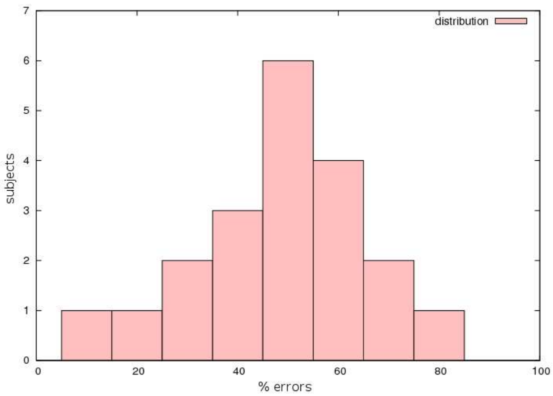

Figure 7: Players distribution according to their errors.

The better credibility of the autonomous players matches to 50% errors per user. Indeed, in this case, this user does not differentiate an avatar from an autonomous player. Figure 7 illustrates the distribution of users according to their error rates.

Even if the number of persons is limited, they do about five exercises each and the results are promising. They tend to show that the behavior of our virtual players creates trouble in the minds of most participants. Then, this experimentation is conclusive.

Nevertheless, it is only an evaluation of the behavioral credibility (the first of our assertions). We now have to evaluate the relevance of our approach for the learning and the understanding of collaborative and dynamical situations.

4 Conclusion

This article has sought to provide a framework of co-construction to study dynamic and collaborative situation. In addition to providing a theoretical modeling, it remains to do further development and an effective construction of knowledge through simulation within different protagonists. As suggested in introduction, expert players are not first concerned by such an approach. However, decision making skills can be trained by players, referees or coaches. The fact that the user can interact with virtual agents' perception parameters allows to test hypothesis. In this view, the user is constructing a representation through the two loops presented in section 2.1.

Like most propositions, this one presents some limits. For example, we bet that expert decision maker use definite perception during CBR elaboration step. A really psychological expertise is needed to minimize this bias. A second limit concerns collective behavioral credibility obtained through agents interactions. Our first investigation focuses on individual credibility and is not sufficient. To evaluate collective behavior, we actually hold investigations with expert football players. This research aims to observe emergent representation thanks to actions of multiplayers in our virtual environment as [27] propose.

References

[1] A. Aamodt and E. Plaza. Casebased reasoning: Foundational issues, methodological variations, and system approaches. *AI Communication*, 7(1):39–59, 1994.

[2] M.T. Argilaga and G.K. Jonsson. Detection of real-time patterns in sports: Interactions in soccer. *International Journal of Computer Science in Sport*, Volume 2/Edition 2(1):118–121, 2003.

[3] R. Bénard. *Raisonnement en contexte pour la simulation participative et l'étude des situations dynamiques collaboratives. Application aux sports collectifs.* PhD thesis, Universit de Bretagne Occidentale, novembre 2007.

[4] R. Bénard, C. Bossard, and P. De Loor. Context's modeling for participative simulation. In Geoff Sutcliffe and Randy Goebel, editors, *19th*

International Florida Artificial Intelligence Research Society Conference (FLAIRS-06), pages 613–618. The AAAI Press, Menlo Park, California, 2006.

[5] R. Bénard, P. De Loor, and J. Tisseau. Understanding dynamic situations through context explanation. In *ICALT*, pages 1044–1046, 2006.

[6] M.H. Bickhard. Interaction and representation. *Theory and representation*, 9(4):435–458, 1999.

[7] P. Brézillon. Context in problem solving: a survey. *Knowl. Eng. Rev.*, 14(1):47–80, 1999.

[8] C. Buche, R. Querrec, P. De Loor, and P. Chevaillier. MASCARET: Pedagogical multi-agents system for virtual environment for training. *Journal of Distance Education Technologies*, 2(4):41–61, 2004.

[9] J. A. Cannon-Bowers, E. Salas, and J.S. Pruitt. Establishing the boundaries of a paradigm for decision-making research. *Human Factors*, 38(2):193–205, 1996.

[10] Marc Cavazza and Stéphane Donikian, editors. Virtual Storytelling. Using Virtual Reality Technologies for Storytelling, *4th International Conference, ICVS 2007*, Saint-Malo, France, December 5-7, 2007, Proceedings, volume 4871 of Lecture Notes in Computer Science. Springer, 2007.

[11] Pierre-Antoine Champin, Yannick Pri, and Alain Mille. MUSETTE: Modeling USEs and Tasks for Tracing Experience. In *Workshop 5 'From Structured Cases to Unstructured Problem Solving Episodes For Experience-Based Assistance', ICCBR' 03*, pages 279–286, June 2003.

[12] Pierre-Antoine Champin, Yannick Pri, and Alain Mille. MUSETTE : a framework for Knowledge from Experience. In *EGC'04, RNTI-E-2 (article court)*, pages 129–134. Cepadues Edition, 2004.

[13] P. Dillenbourg. What do you mean by collaborative learning? In P. Dillenbourg, editor, *Collaborative-learning: Cognitive and Computational Approaches*, pages 1– 19. Oxford: Elsevier, 1999.

[14] J. Ferber. *Multi-Agent System: An Introduction to Distributed Artificial Intelligence*. Harlow: Addison Wesley Longman, 1999.

[15] A.J. Gonzalez and R. Ahlers. Contextbased representation of intelligent behavior in training simulations. *Trans. Soc. Comput. Simul. Int.*, 15(4):153–166, 1998.

[16] F Harrouet, T Jourdan, and E. Cazeaux. Arévi. (3), September 2006.

[17] D. Herviou. *La perception visuelle des entits autonomes en ralit virtuelle : Application la simulation de trafic routier*. PhD thesis, Universit de Bretagne Occidentale, 2006.

[18] J.H. Holland. *Adaptation in Natural and Artificial Systems*. University of Michigan Press, Ann Arbor, 1975. Republished by the MIT press, 1992.

[19] Alankar Karol, Bernhard Nebel, Christopher Stanton, and Mary-Anne Williams. Case based game play in the robocup fourlegged league part i the theoretical model. In *RoboCup 2003: Robot Soccer World Cup VII*, Lecture Notes in Computer Science, pages 739–747. Springer, 2003.

[20] R. L. Oser, J.W. Gualtieri, J.A Cannon- Bowers, and E. Salas. Training team problem solving skills: an event-based approach. *Computers in Human Behavior*, 15:441–462, 1999.

[21] J. Piaget. *L'épistémologie génétique*. Paris, 1970.

[22] Raquel Ros, Manuela Veloso, Ramon Lopez de Mantaras, Carles Sierra, and Josep Lluis Arcos. Retrieving and reusing game plays for robot soccer. In *Lecture Notes in Computer Science, Proceedings of ECCBR-2006*, Oludeniz, Turkey, September 2006. Best Paper Award.

[23] E. Salas, R. L. Oser, J.A. Cannon-Bowers, and E. Daskarolis-Kring. *Handbook of virtual environments: Design, implementation and applications*, chapter Team training in virtual environments: An eventbased approach, pages 873–892. NJ, Lawrence Erlbaum Associates, 2002.

[24] C. Sanza, C. Panatier, and Y. Duthen. Adaptive behavior for cooperation: a virtual reality application. In IEEE USA, editor, *RO-MAN'99, 8th IEEE International Workshop on Robot and Human Interaction, Pise, Italie*, pages 76–81, 1999.

[25] Roger C. Schank. *Dynamic Memory Revisited*. Cambridge University Press, 1999.

[26] R. Sutton and A. Barto. *Reinforcement Learning*. Cambridge, MA: MIT Press, 1998.

[27] Goran Trajkovski and Samuel G. Collins. Autonomy through self-organization: Interactivism and emergence in a virtual environment. *New ideas in psychology*, 24:99–116, 2006.

[28] F.J. Varela, E. Thompson, and E. Rosch. *The Embodied Mind*. MIT Press, 1993.